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Best Management Practices for Nitrogen Use in NORTHWESTERN MINNESOTA

BEST MANAGEMENT PRACTICES FOR NITROGEN APPLICATION

Best Management Practices for Nitrogen Use in Northwestern Minnesota

Albert Sims, Associate Professor and Soil Scientist, Northwest Research and Outreach Center; George Rehm, Nutrient Management Specialist (retired); John Lamb, Professor, University of Minnesota.

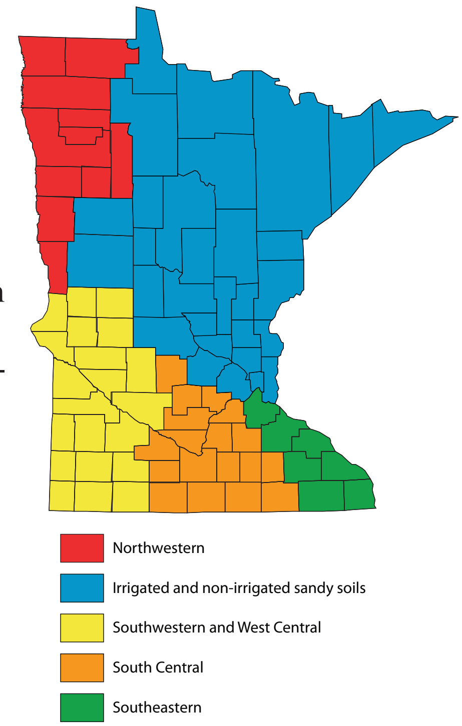
Introduction

Nitrogen (N) is absorbed in large amounts by Minnesota crops. It is the major nutrient supplied in a fertilizer program. In addition, large quantities of nitrogen are part of the crop production ecosystem including soil organic matter. Biological processes that convert nitrogen to its usable and mobile form (NO_3) occur continuously in the soil system, primarily in the soil organic matter. Nitrogen in soil exists in several forms and conversion from one form to another can be complex. For a more detailed description of the dynamics of nitrogen in soils see: "***Understanding Nitrogen in Soil***", **FO-3770**, **Minnesota Extension Service**.

While it is recognized that there is substantial diversity in crop production systems coupled with a wide variety of soils in northwestern Minnesota, this publication will focus on small grain production. The BMP's described in the publication "***Best-Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota***" are appropriate for corn production in northwestern Minnesota. The BMP's listed in that publication are also appropriate for sugarbeet production in the region. For sandy soils in northwestern Minnesota, BMP's listed in the publication, "***Best Management Practices for Nitrogen on Coarse-Textured Soils***" are appropriate.

What are Best Management Practices (BMP's)?

There is general agreement that BMP's are economically sound voluntary practices that, if used, are capable of minimizing nitrogen loss to the environment and maximizing utilization by the crop. The BMP's listed in this publication are based on extensive research conducted by faculty of the University of Minnesota and neighboring Land Grant Institutions. The BMP's relate to management of all sources of nitrogen used in production of small grain in northwestern Minnesota.



BMP's for Northwestern Minnesota

The BMP's in this publication are focused on wheat production. The BMP's are also divided into three categories described as, 1) recommended, 2) acceptable but with greater risk, and 3) not recommended. With respect to N management, risks can be either economic or environmental. Economic risk can be a consequence of added input costs without additional yield or a reduction in yield. Environmental risks pertain to the potential for loss of nitrogen to either ground water or surface waters.

For northwestern Minnesota, the BMP's are:

1) Recommended

- Base rate of nitrogen applied on expected yield, with some general consideration of soil organic matter content and previous crop

- Total N rate should include all fertilizer sources including contributions from phosphate fertilizer, such as DAP or MAP.
- For ammonium based products (AA or urea), apply when soil temperatures at 6 inches stabilize below 50°F either broadcast or banded at planting.
- Take credit for nitrogen supplied by previous legume crops in the rotation.
- Take credit for available nitrogen supplied in manure or the nitrogen contained in sugarbeet tops based on leaf color prior to beet harvest.
- Adjust the nitrogen rate for measured residual nitrate-nitrogen in the surface 2 feet of the soil profile when wheat follows a non-legume crop in a rotation.
- Collect soil samples in increments of 0 to 6 and 6 to 24 inches after soil temperatures at 6 inches stabilizes at 50°F.
- Any broadcast urea, should be incorporated to a depth of 3 inches.

2) Acceptable, But With Greater Risk

- Limit rate to 40 lb. N per acre if a liquid source of nitrogen is applied to foliage at the boot stage or later.
- Application of urea in a band either with the seed or near the seed when an air seeder is used for planting.

3) Not Recommended

- Fall application of liquid nitrogen (28-0-0) or any fertilizer containing nitrate-nitrogen.
- Fall or spring application of urea without incorporation.
- Shallow (2 inches or less) application of 82-0-0 in either fall or spring.
- Foliar application of high rates of 28-0-0 (more than 40 lb. N per acre) at boot stage or later.
- Application of any N fertilizers including MAP or DAP on frozen soils.
- Fall application of N, regardless of source, to sandy soils in the fall.

Selecting a Nitrogen Rate

There are two ways to choose a rate of N for production of hard red spring wheat. The first is based on expected yield, previous crop and soil organic matter content (see Table 1). In using Table 1, the previous crops are grouped as follows:

Group 1	Group 2		
alsike clover	barley	grass pasture	sugarbeet
birdsfoot trefoil	buckwheat	millet	sunflower
grass/legume hay	canola	oats	triticale
grass/legume pasture	corn	potatoes	wheat
fallow	grass hay	rye	vegetables
red clover		sorghum-sudan	

Sampling soil for measurement of NO_3-N is not suggested when wheat follows a legume crop in the rotation. Legumes can extract considerable NO_3-N from the root zone leaving uniform amounts of NO_3-N that are relatively low.

Collection of soil samples from depths of 0 to 8 and 8 to 24 inches is suggested for cropping systems where wheat follows a crop other than a legume in rotation. The surface soil (0 to 8 inches) should be analyzed for pH, phosphorus, potassium, and zinc. This soil sample along with soil collected from 8 to 24 inches should be analyzed for nitrate-nitrogen.

If residual nitrate-nitrogen is measured, the suggested rate of nitrogen is derived from the following equation:

$$N_{Rec} = (2.5)\ EY\text{-}STN_{\ (0\text{-}24\ in)}$$

where: EY = expected yield (bu./acre)

STN = nitrate-nitrogen (NO_3-N) measured to a depth of 2 feet, lb./acre

Special attention should be given to the time of sample collection. These soil samples should be collected after soil temperature at a depth of 6 inches drops below 50°F. Nitrate-nitrogen in soil undergoes various transformations at higher temperatures. Therefore, accurate information may not be possible if soil samples are collected when soil temperatures are warmer.

Table 1. Nitrogen guidelines for hard red spring wheat where the soil nitrate test is not used.

Crop Grown Last Year	Organic Matter[1]	Expected Yield (bu./acre) 40-49	50-59	60-69	70-79	80+
		- - N to apply (lb. N/acre) - -				
alfalfa (4+ plants/ft^2)	low	0	30	55	80	95
	medium and high	0	0	35	60	75
alfalfa (2-3 plants/ft^2)	low	10	35	60	85	100
	medium and high	0	15	40	65	80
soybeans, alfalfa (1 or less plants/ft^2)	low	60	85	110	135	150
	medium and high	40	65	90	115	130
edible beans, field peas	low	70	95	120	145	160
	medium and high	50	75	100	125	140
group 1 crops	low	30	55	80	105	120
	medium and high	0	35	60	85	100
group 2 crops	low	80	105	130	155	170
	medium and high	60	85	110	135	150
organic soil		0	0	0	30	35

[1] low = less than 3.0%; medium and high = 3.0% or more

Tops of a previous crop of sugarbeets can supply nitrogen to the wheat crop. Some adjustment in rate of applied N should be made as indicated by the color of the tops (use Table 2). The values listed in Table 2 should be subtracted from the N guidelines in Table 1.

Table 2. Nitrogen adjustments when a sugarbeet crop precedes wheat in the rotation.

Color of Sugarbeet Tops	N Credit
	lb. N / acre
yellow leaves at harvest	0
light green leaves at harvest	30
dark green leaves at harvest	80

Nitrogen rate guidelines for corn can be found in the publication **"*Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota*", AG-FO-6128 (revised)**.

Take Credit for Nitrogen Supplied from Previous Crops and Livestock Manure

The nitrogen credit for the previous crops is accounted for in Tables 1 and 2. It is also important to take credit for nitrogen supplied in livestock manure. The variability in the availability of nitrogen in manures is substantial and appropriate practices for sampling and application are discussed in bulletins listed at the end of this publication.

Method and Time of Application

Nitrogen fertilizers can be applied in either fall or spring. Two sources (AA, urea) are appropriate for fall application. If applied in a way to prevent N loss, both sources have an equal effect on yield (Table 3). With UAN, 25% of the N is present as nitrate-nitrogen. This nitrate-nitrogen is subject to loss - - primarily as denitrification. Therefore, fall application of UAN **is not** recommended.

Depth of placement is an important consideration for nitrogen applied in the fall. Incorporation or placement at depths less than 2 inches increases the probability of loss due to volatilization (application of AA) or denitrification (both AA and urea) if applied N is converted to nitrate-nitrogen in the fall. Therefore, placement of AA at a depth of 4 inches or greater is suggested. Likewise, incorporation of fall applied urea to a depth of 3 inches or greater is suggested.

When applied in the spring, all sources of fertilizer N have had an equal effect on yield (Table 4). Incorporation of urea and UAN is also suggested when these sources of nitrogen are applied in the spring before planting.

Suggestions for nitrogen application discussed in the previous paragraphs are appropriate when wheat is seeded with a drill. The use of air seeders for planting raises new questions about nitrogen placement and rate for production of hard red spring wheat. With this method of seeding, there are several options for placement of nitrogen fertilizers.

The wheat yields in Tables 3 and 4 are from research trials where the nitrogen was applied before planting. When drills are used, it is possible to apply urea with the seed. This is an acceptable practice if rates of applied nitrogen are not high (Table 5). Although yields increased with nitrogen rates up to 50 lb. per acre, the negative impact on emergence is a major concern. At nitrogen rates in excess of 50 lb. per acre, there was a negative effect on emergence.

Recently, a study was conducted in northwest Minnesota for the purpose of evaluating various placement options when urea was applied with an air seeder at planting. Wheat emergence and grain yields were measured (Figures 1 and 2). The urea was applied at rates to supply 25, 50, and 75 lb. nitrogen per acre.

Table 3. Yield of hard red spring wheat as affected by rate of application of two nitrogen sources applied in the field.

N Applied	Urea (46-0-0)	AA (82-0-0)
lb./acre	- - - - bu./acre	- - - -
50	39	40
75	40	40
100	41	41

yield of control = 30 bu. / acre

Table 4. Yield of hard red spring wheat as affected by three nitrogen sources applied in the spring.

N Applied	UAN (28-0-0)	Urea (46-0-0)	AA (82-0-0)
lb./acre	- - - - - -	bu./acre	- - - - -
100	76	78	80

yield of control = 58 bu./acre

Table 5. Emergence of hard red spring wheat and yield as affected by rate of nitrogen supplied as urea with the seed in a grain drill.

N Applied	Emerged Population	Yield
lb. / acre	plants / acre	bu. / acre
0	683,890	36
25	649,900	51
50	606,350	57
75	506,170	57
100	470,450	49

Some explanation of the various placements is needed. With the BB placement, the 46-0-0 was applied in a band to the side of the seed. The fertilizer and wheat seed were applied in the same band in the BM placement. With the air seeder, the seed and fertilizer mixed together are in a more concentrated band compared to seed and fertilizer mixed and a grain drill is used. The seed/fertilizer mixture was placed at the typical depth for planting wheat. For the TB placement, the seed was split into 2 rows about 3 to 4 inches apart and the fertilizer was placed in a band between the rows. Seed and fertilizer were mixed in a band that was about 3 inches wide in the SM placement. Emergence was reduced as the rate of N increased when the fertilizer and seed were mixed together (Figure 1). The reduction in emergence was less severe when the seed/fertilizer mixture was applied in a wide (SM) rather than a narrow (BM) band.

Measured yields are shown in Figure 2. A substantial reduction in yield was measured when the urea was applied at rates to supply 50 and 75 lb. nitrogen per acre in a narrow band with the seed. Otherwise, the wheat was able to tiller when there was a less severe reduction in emergence and yield was not negatively affected.

Spacing of rows is not constant on all air seeders. Therefore, it is logical to expect that limits to the rate of urea applied with the seed would vary with row spacing and the seeding implement used. North Dakota State University has proposed limits for various planter types and seed spread (Table 6). The lower end of the range is appropriate for coarse-textured soils. The upper end of each range is appropriate for fine-textured soils.

Table 6. Maximum urea-nitrogen fertilizer rates suggested with spring wheat at planting as affected by planter spacing, type, and seed spread.

Planter Type	Seed Spread	Planter Spacing (inches) 6	7.5	10	12
	inches	---- lb. urea-nitrogen / acre ----			
double disc	--	20-30	19-28	17-23	15-20
hoe opener	--	32-44	27-38	23-31	20-27
air seeder	4	56-72	46-58	37-48	32-42
	5	68-86	56-68	44-57	38-49
	6	80-100	66-79	51-55	44-56
	7	--	76-90	58-74	50-64
	8	--	--	66-83	56-71

Source: Extension Circular EB-62, North Dakota State University

Potential Helpful Products

There is general recognition that nitrogen can be lost from soils. Responding to that recognition, products have been developed that, when used, could reduce the potential for loss. N-Serve is a nitrification inhibitor used for the purpose of delaying the conversion of ammonium (NH_4^+-N) to nitrate (NO_3-N). When considering small grain production in northwestern Minnesota, there is no reason to delay this nitrification reaction. So, the use of this product is not part of the Best Management Practices.

Agrotain is a urease inhibitor designed to be used in no-till or other production systems where urea remains on the soil surface without incorporation. Unless hard red spring wheat is grown with no-till production practices, the use of Agrotain is not included in the Best Management Practices.

ESN is a product that consists of urea coated with a polymer and thus, is intended for use as a slow release nitrogen fertilizer. Trials to evaluate this product for grain yield and grain protein were just initiated and there are currently no conclusions.

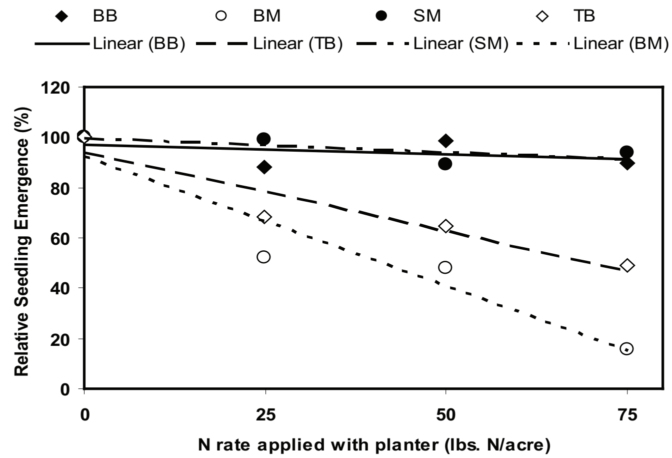


Figure 1. Relative Seedling emergence of hard red spring wheat as affected by rate and placement of urea nitrogen in 1998.

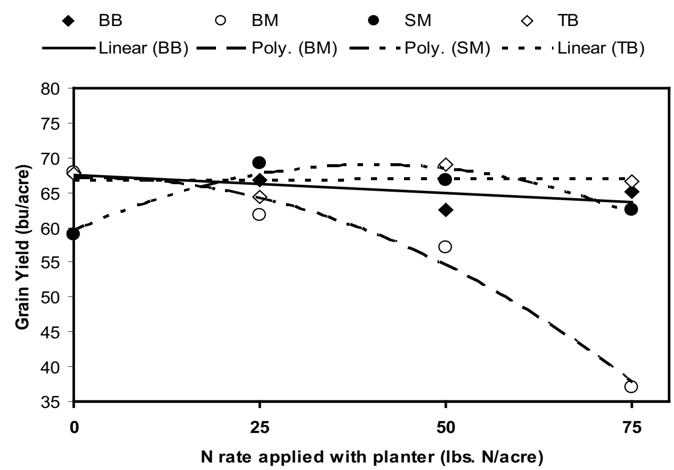


Figure 2. Grain yield of hard red spring wheat as affected by rate and placement of urea nitrogen in 1998.

Summary

Effective and efficient management of nitrogen fertilizers is important for profitable small grain production in northwestern Minnesota. The research based Best Management Practices (BMP's) described in this publication are agronomically, economically, and environmentally sound. They are voluntary. If these practices are followed, agriculture can be more profitable without the threat of regulation.

Related Publications

08560 (revised, 2008) - Best Management Practices for Nitrogen Use in Minnesota

08557 (revised, 2008) - Best Management Practices for Nitrogen Use in Southeastern Minnesota

08554 (revised, 2008) - Best Management Practices for Nitrogen Use in South-Central Minnesota

08558 (revised, 2008) - Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota

08556 (revised, 2008) - Best Management Practices for Nitrogen Use on Coarse-Textured Soils

AG-FO-5880 - Fertilizing Cropland with Dairy Manure

AG-FO-5879 - Fertilizing Cropland with Swine Manure

AG-FO-5881 - Fertilizing Cropland with Poultry Manure

AG-FO-5882 - Fertilizing Cropland with Beef Manure

AG-FO-3790 - Fertilizing Corn in Minnesota

AG-FO-3770 - Understanding Nitrogen in Soils

AG-FO-3774 - Nitrification Inhibitors and Use in Minnesota

AG-FO-2774 - Using the Soil Nitrate Test for Corn in Minnesota

AG-FO-2392 Managing Nitrogen for Corn Production on Irrigated Sandy Soils

AG-FO-0636 - Fertilizer Urea

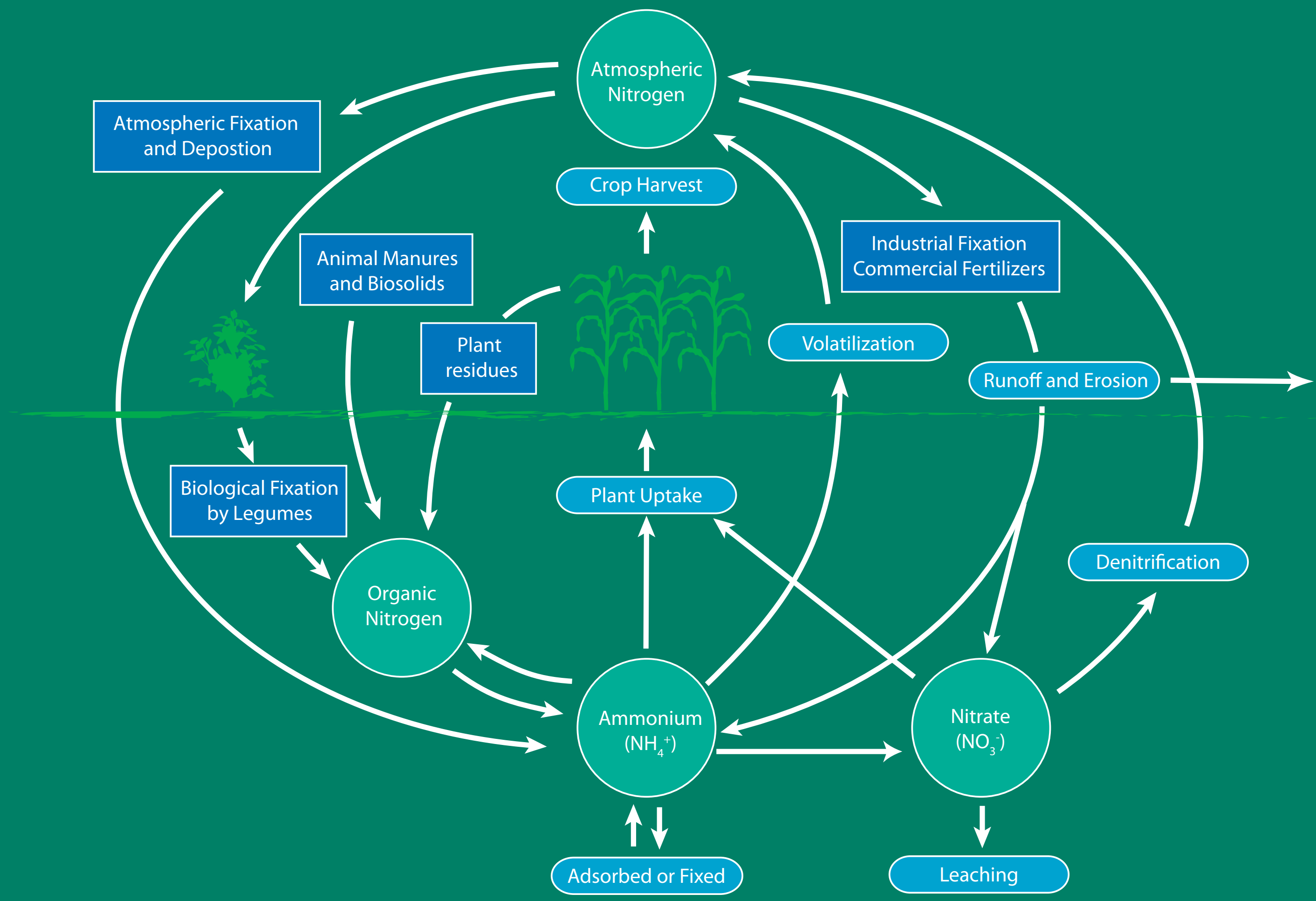
AG-FO-3073 - Using Anhydrous Ammonia in Minnesota

AG-FO-6074 - Fertilizer Management for Corn Planted in Ridge-till or No-till Systems

AG-FO-3553 - Manure Management in Minnesota

BU-07936 - Validating N Rates for Corn

Iowa State Univ. PM 2015 - Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn



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PUBLICATION # 08555